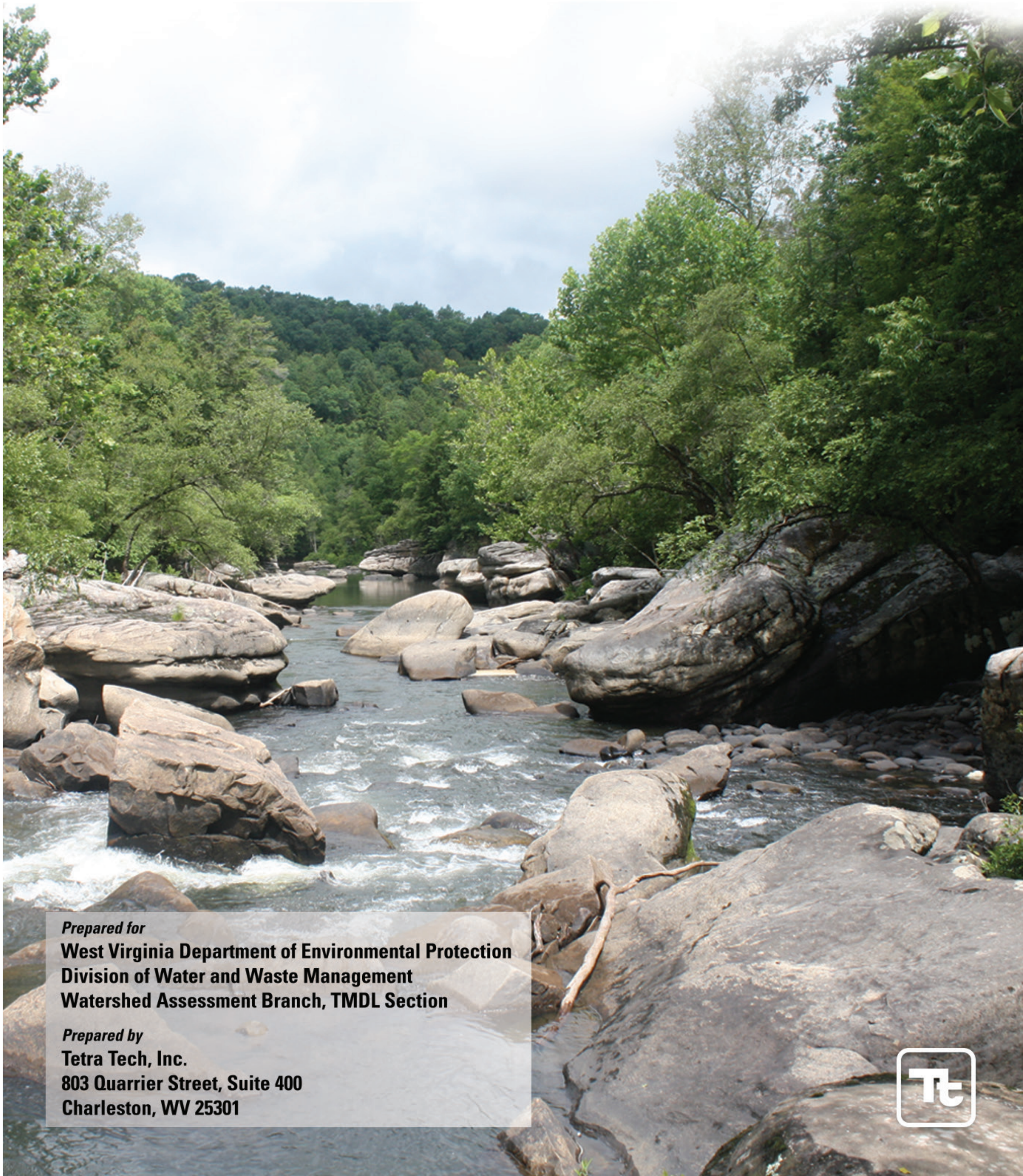
November 2016

USEPA Approved Report

Total Maximum Daily Loads for the Meadow River Watershed, WV



Prepared for
West Virginia Department of Environmental Protection
Division of Water and Waste Management
Watershed Assessment Branch, TMDL Section

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On the cover: Meadow River
Photo provided by WVDEP Division of Water and Waste Management

CONTENTS

TABLES

FIGURES

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

7Q10	7-day, 10-year low flow
AD	Acid Deposition
AML	abandoned mine land
CFR	Code of Federal Regulations
CSO	combined sewer overflow
CSR	Code of State Rules
DEM	Digital Elevation Model
DMR	[WVDEP] Division of Mining and Reclamation
DNR	West Virginia Division of Natural Resources
DO	dissolved oxygen
DWWM	[WVDEP] Division of Water and Waste Management
ERIS	Environmental Resources Information System
GIS	geographic information system
gpd	gallons per day

HAU	home aeration unit
LA	load allocation
µg/L	micrograms per liter
MDAS	Mining Data Analysis System
mg/L	milligrams per liter
mL	milliliter
MF	membrane filter counts per test
MPN	most probable number
MOS	margin of safety
MRLC	Multi-Resolution Land Characteristics Consortium
MS4	Municipal Separate Storm Sewer System
NED	National Elevation Dataset
NLCD	National Land Cover Dataset
NOAA-NCDC	National Oceanic and Atmospheric Administration, National Climatic Data Center
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OOG	[WVDEP] Office of Oil and Gas
POTW	publicly owned treatment works
SI	stressor identification
SRF	State Revolving Fund
SSO	sanitary sewer overflow
STATSGO	State Soil Geographic database
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UNT	unnamed tributary
WLA	wasteload allocation
WVDEP	West Virginia Department of Environmental Protection
WVU	West Virginia University

Watershed

A general term used to describe a drainage area within the boundary of a United States Geologic Survey's 8-digit hydrologic unit code. Throughout this report, the Meadow River Watershed refers to the tributary streams that ultimately drain to the Meadow River (**Figure I-1**). The term "watershed" is also used more generally to refer to the land area that contributes precipitation runoff that eventually drains to the mouth of the Meadow River.

TMDL Watershed

This term is used to describe the total land area draining to an impaired stream for which a TMDL is being developed. This term also takes into account the land area drained by un-impaired tributaries of the impaired stream, and may include impaired tributaries for which additional TMDLs are presented. This report addresses 20 impaired streams contained within 13 TMDL watersheds in the Meadow River Watershed.

Subwatershed

The subwatershed delineation is the most detailed scale of the delineation that breaks each TMDL watershed into numerous catchments for modeling purposes. The 13 TMDL watersheds have been subdivided into 170 modeled subwatersheds. Pollutant sources, allocations and reductions are presented at the subwatershed scale to facilitate future permitting actions and TMDL implementation.

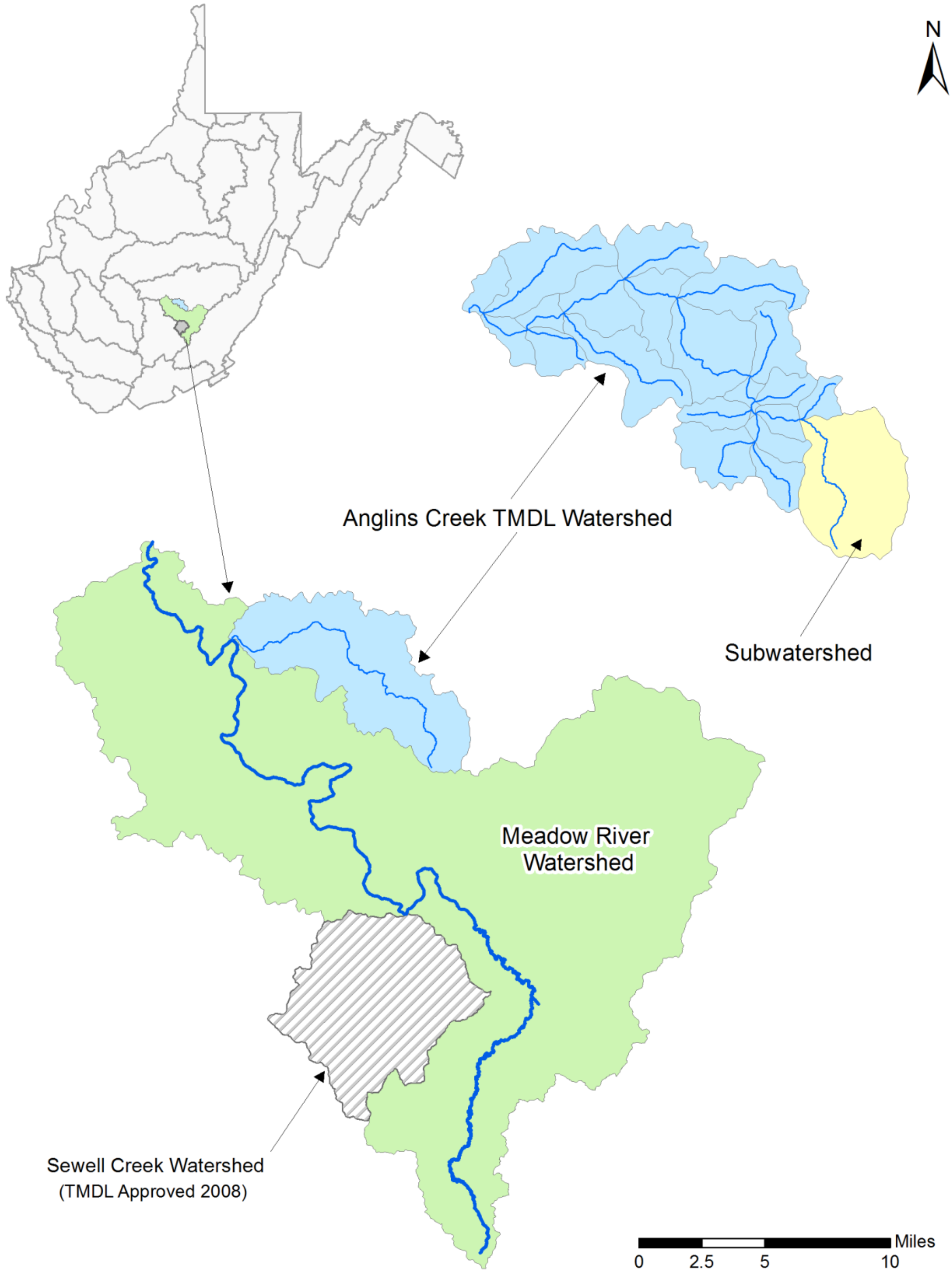

Figure I-1. Examples of a watershed, TMDL watershed, and subwatershed

EXECUTIVE SUMMARY

This report includes Total Maximum Daily Loads (TMDLs) for 20 impaired streams in the Meadow River watershed. This project was organized into 13 TMDL watersheds, which account for all streams draining to the Meadow River.

A TMDL establishes the maximum allowable pollutant loading for a waterbody to comply with water quality standards, distributes the load among pollutant sources, and provides a basis for actions needed to restore water quality. West Virginia's water quality standards are codified at Title 47 of the *Code of State Rules* (CSR), Series 2, and titled *Legislative Rules, Department of Environmental Protection: Requirements Governing Water Quality Standards*. The standards include designated uses of West Virginia waters and numeric and narrative criteria to protect those uses. The West Virginia Department of Environmental Protection routinely assesses use support by comparing observed water quality data with criteria and reports impaired waters every two years as required by Section 303(d) of the Clean Water Act ("303(d) list"). The Act requires that TMDLs be developed for listed impaired waters.

Some impaired streams for which TMDLs are presented were identified on past West Virginia Section 303(d) Lists. Others will be included on the West Virginia's draft 2016 Section 303(d) List. Documented impairments are related to numeric water quality criteria for pH and fecal coliform bacteria.

Impaired waters were organized into 13 TMDL watersheds. For hydrologic modeling purposes, impaired and unimpaired streams in these 13 TMDL watersheds were further divided into 170 smaller subwatershed units. The subwatershed delineation provided a basis for georeferencing pertinent source information, monitoring data, and presentation of the TMDLs.

The Mining Data Analysis System (MDAS) was used to represent linkage between pollutant sources and instream responses for fecal coliform bacteria and pH. The MDAS is a comprehensive data management and modeling system that is capable of representing loads from nonpoint and point sources in the watershed and simulating instream processes.

In general, point and nonpoint sources contribute to the fecal coliform bacteria impairments in the watershed. Failing on-site septic systems, direct discharges of untreated sewage, and precipitation runoff from agricultural and residential areas are nonpoint sources of fecal coliform bacteria. Point sources of fecal coliform bacteria include the effluents of sewage treatment facilities. The presence of individual source categories and their relative significance varies by subwatershed.

The pH impairments in the watershed are solely attributable to acid precipitation. In certain watersheds with low buffering capacity, acidic precipitation decreases pH below the pH criterion. Pollutant reductions are measured and expressed in the amount of alkalinity needed to offset the acid load.

This report describes the TMDL development and modeling processes, identifies impaired streams and existing pollutant sources, discusses future growth and TMDL achievability, and documents the public participation associated with the process. It also contains a detailed discussion of the allocation methodologies applied for various impairments. Various provisions attempt to ensure the attainment of criteria throughout the watershed, achieve equity among categories of sources, and target pollutant reductions from the most problematic sources.

In 2008, WVDEP developed fecal coliform TMDLs (WVDEP, 2008) for Sewell Creek watershed. The 2008 TMDLs were not re-evaluated during the water quality modeling effort described in this report. The output of the 2008 Sewell Creek TMDL was a boundary condition for this modeling effort. Fecal coliform load allocations and wasteload allocations from the 2008 TMDL remain operative.

Considerable resources were used to acquire recent water quality and pollutant source information upon which the TMDLs are based. The TMDL modeling is among the most sophisticated available, and incorporates sound scientific principles. TMDL outputs are presented in various formats to assist user comprehension and facilitate use in implementation, including allocation spreadsheets, an ArcGIS Viewer Project, and Technical Report.

Applicable TMDLs are displayed in **Section 7** of this report. The accompanying spreadsheets provide TMDLs and allocations of loads to categories of point and nonpoint sources that achieve the total TMDL. Also provided is the ArcGIS Viewer Project that allows for the exploration of spatial relationships among the source assessment data. A Technical Report is available that describes the detailed technical approaches used in the process and displays the data upon which the TMDLs are based.

1.0 REPORT FORMAT

This report describes the overall total maximum daily load (TMDL) development process for select streams in the Meadow River Watershed, identifies impaired streams, and outlines the source assessment for all pollutants for which TMDLs are presented. It also describes the modeling and allocation processes and lists measures that will be taken to ensure that the TMDLs are met. The applicable TMDLs are displayed in **Section 7** of this report. The report is supported by an ArcGIS Viewer Project that provides further details on the data and allows the user to explore the spatial relationships among the source assessment data, magnify streams and view other features of interest. In addition to the TMDL report, a CD is provided that contains spreadsheets (in Microsoft Excel format) that display detailed source allocations associated with successful TMDL scenarios. A Technical Report is included that describes the detailed technical approaches used in the process and displays the data upon which the TMDLs are based.

2.0 INTRODUCTION

The West Virginia Department of Environmental Protection (WVDEP), Division of Water and Waste Management (DWWM), is responsible for the protection, restoration, and enhancement of the State's waters. Along with this duty comes the responsibility for TMDL development in West Virginia.

2.1 Total Maximum Daily Loads

Section 303(d) of the federal Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to identify waterbodies that do not meet water quality standards and to develop appropriate TMDLs. A TMDL establishes the maximum allowable pollutant loading for a waterbody to achieve compliance with applicable standards. It also distributes the load among pollutant sources and provides a basis for the actions needed to restore water quality.

A TMDL is composed of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. TMDLs can be expressed in terms of mass per time or other appropriate units. Conceptually, this definition is denoted by the following equation:

$$\text{TMDL} = \text{sum of WLAs} + \text{sum of LAs} + \text{MOS}$$

WVDEP is developing TMDLs in concert with a geographically-based approach to water resource management in West Virginia—the Watershed Management Framework. Adherence to the Framework ensures efficient and systematic TMDL development. Each year, TMDLs are developed in specific geographic areas. The Framework dictates that 2016 TMDLs should be pursued in Hydrologic Group C, which includes the Gauley River Watershed, of which Meadow

River Watershed is a part. **Figure 2-1** depicts the hydrologic groupings of West Virginia's watersheds; the legend includes the target year for finalization of each TMDL.

WVDEP is committed to implementing a TMDL process that reflects the requirements of the TMDL regulations, provides for the achievement of water quality standards, and ensures that ample stakeholder participation is achieved in the development and implementation of TMDLs. A 48-month development process enables the agency to carry out an extensive data generating and gathering effort to produce scientifically defensible TMDLs. It also allows ample time for modeling, report finalization, and frequent public participation opportunities.

The TMDL development process begins with pre-TMDL water quality monitoring and source identification and characterization. Informational public meetings are held in the affected watersheds. Data obtained from pre-TMDL efforts are compiled, and the impaired waters are modeled to determine baseline conditions and the gross pollutant reductions needed to achieve water quality standards. The draft TMDL is advertised for public review and comment, and an informational meeting is held during the public comment period. Public comments are addressed, and the draft TMDL is submitted to USEPA for approval.

In 2008, WVDEP developed fecal coliform TMDLs (WVDEP, 2008) for Sewell Creek watershed. The 2008 TMDLs were not re-evaluated during the water quality modeling effort described in this report. The output of the 2008 Sewell Creek TMDL was a boundary condition for this modeling effort. Fecal coliform load allocations and wasteload allocations from the 2008 TMDL remain operative.

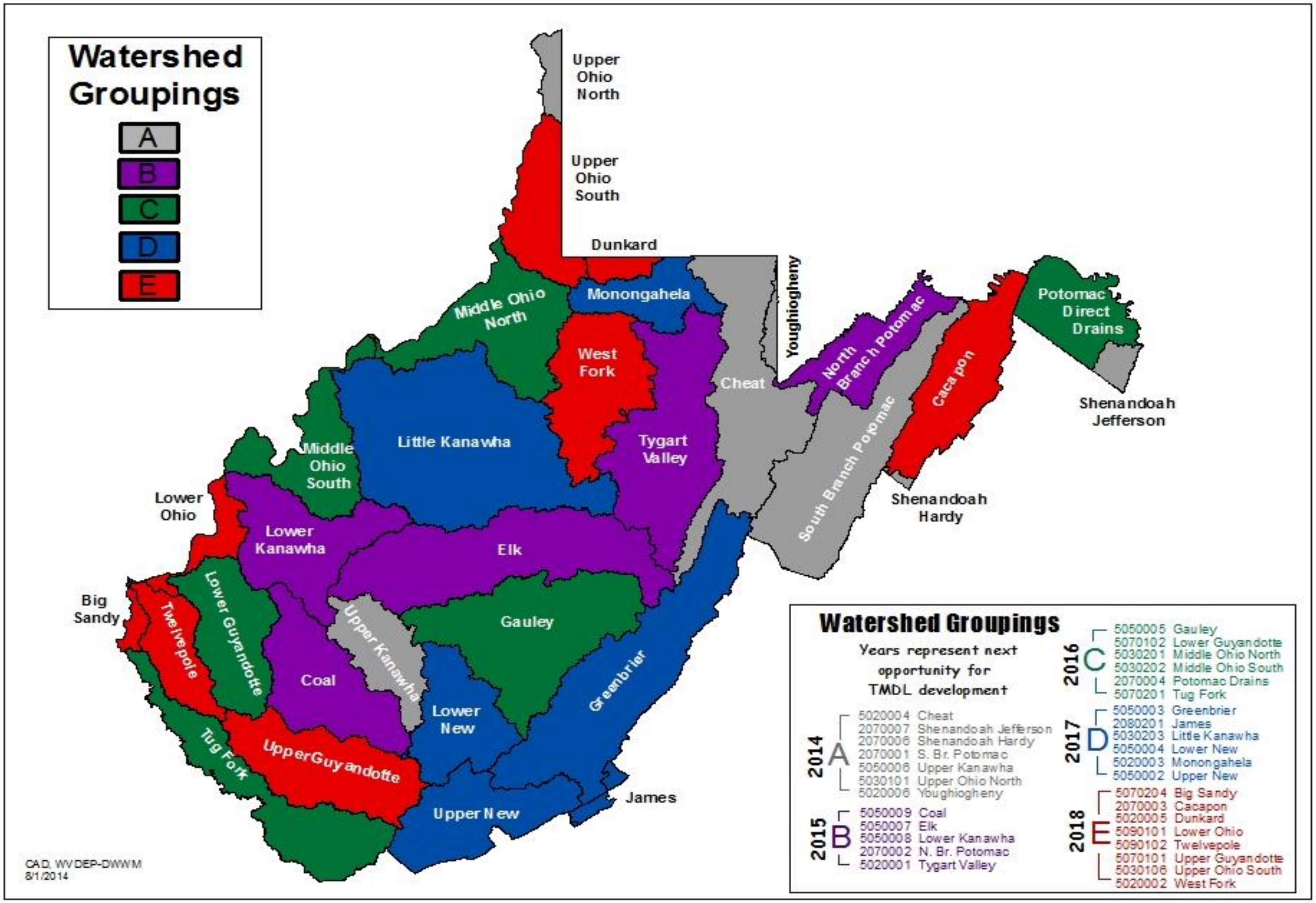

Figure 2-1. Hydrologic groupings of West Virginia's watersheds

2.2 Water Quality Standards

The determination of impaired waters involves comparing instream conditions to applicable water quality standards. West Virginia's water quality standards are codified at Title 47 of the *Code of State Rules* (CSR), Series 2, titled *Legislative Rules, Department of Environmental Protection: Requirements Governing Water Quality Standards*. These standards can be obtained online from the West Virginia Secretary of State Internet site (http://apps.sos.wv.gov/adlaw/csr/rule.aspx?rule=47-02.)

Water quality standards consist of three components: designated uses; narrative and/or numeric water quality criteria necessary to support those uses; and an antidegradation policy. Appendix E of the Standards contains the numeric water quality criteria for a wide range of parameters, while Section 3 of the Standards contains the narrative water quality criteria.

Designated uses include: propagation and maintenance of aquatic life in warmwater fisheries and troutwaters, water contact recreation, and public water supply. In various streams in the Meadow River Watershed, warmwater fishery aquatic life use impairments and troutwater aquatic life use impairments have been determined pursuant to exceedances of pH numeric water quality criteria. Water contact recreation and/or public water supply use impairments have also been determined in various waters pursuant to exceedances of numeric water quality criteria for fecal coliform bacteria and pH.

The numeric water quality criteria applicable to the impaired streams addressed by this report are summarized in **Table 2-1**. The stream-specific impairments related to numeric water quality criteria are displayed in **Table 3-3**.

TMDLs presented herein are based upon the water quality criteria that are currently effective. If the West Virginia Legislature adopts Water Quality Standard revisions that alter the basis upon which the TMDLs are developed, then the TMDLs and allocations may be modified as warranted. Any future Water Quality Standard revision and/or TMDL modification must receive USEPA approval prior to implementation.

Table 2-1. Applicable West Virginia water quality criteria

<table>
<tr><th rowspan="3">POLLUTANT</th><th colspan="4">USE DESIGNATION</th></tr>
<tr><th colspan="2">Aquatic Life</th><th colspan="2">Human Health</th></tr>
<tr><th>Warmwater Fisheries</th><th>Troutwaters</th><th>Contact Recreation</th><th>Public Water Supply</th></tr>
<tr><td>pH</td><td colspan="4">No values below 6.0 or above 9.0</td></tr>
<tr><td>Fecal coliform bacteria</td><td colspan="2"></td><td colspan="2">Maximum allowable level of fecal coliform content for Primary Contact Recreation (either MPN [most probable number] or MF [membrane filter counts/test]) shall not exceed 200/100 mL as a monthly geometric mean based on not less than 5 samples per month; nor to exceed 400/100 mL in more than 10 percent of all samples taken during the month.</td></tr>
</table>

3.0 WATERSHED DESCRIPTION AND DATA INVENTORY

3.1 Watershed Description

Located within the Central Appalachian ecoregion, the Meadow River is a major tributary of the Gauley River, which flows into the Kanawha River, a major tributary of the Ohio River that joins the Mississippi and flows to the Gulf of Mexico. The Meadow River Watershed consists of land draining to the Meadow River, which begins as a mountain headwater stream in Summers County, and ends at the confluence of the Meadow and Gauley rivers 5 miles below the Summersville Dam. Meadow River is approximately 62 miles (100 km) long, and its watershed encompasses 365 square miles (945 km^2). Of the 365 total square miles in the watershed, only 324 square miles were modeled under this present TMDL effort. The Sewell Creek Watershed was not modeled in this effort because a TMDL exists for the stream.

The Meadow River Watershed lies within the high Allegheny Mountains of southeastern West Virginia, and occupies significant portions of Greenbrier, Fayette and Nicholas counties (**Figure 3-1**). The watershed also falls within a small portion of Summers County. Towns in the vicinity of the area of study are Rupert, Rainelle and Quinwood. The highest point in the modeled portion of the watershed is 4,351 feet above sea level on Beech Ridge, which drains to headwaters of Big Clear Creek. The lowest point in the modeled portion of the watershed is 1,158 feet at the confluence of the Meadow and Gauley rivers. The average elevation in the modeled portion of the watershed is 2,588 feet. The total population living in the subject watersheds of this report is estimated to be 5,000 people.

Major tributaries of the Meadow River include the Glade Creek, Brackens Creek, Anglins Creek, Big Clear Creek, Little Clear Creek, Sewell Creek, and Otter Creek. This project was organized into 13 TMDL watersheds. **Figure 3-2** displays the extent of the Meadow River Watershed and the TMDL watersheds associated with this project.

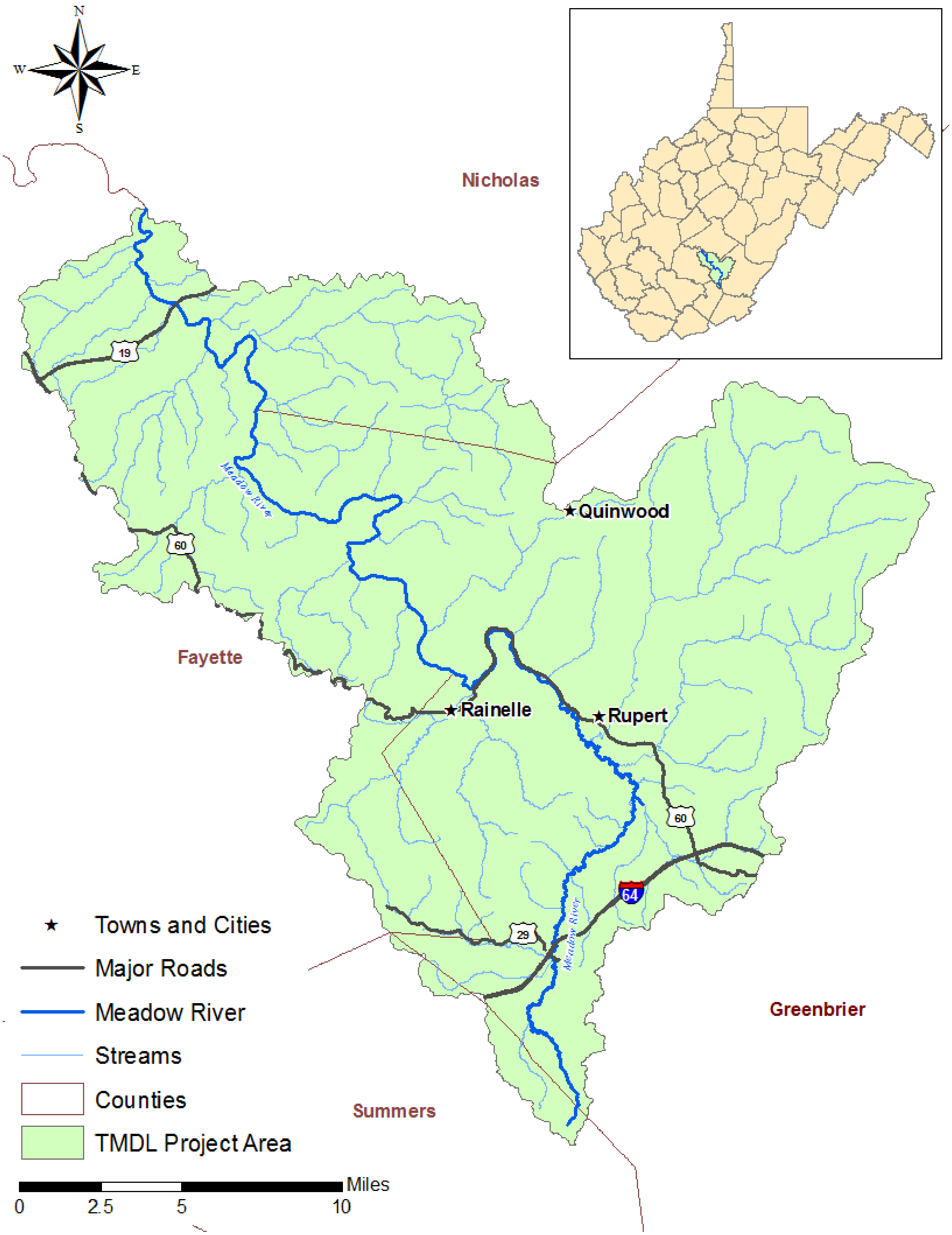

Figure 3-1. Location of the Meadow River Watershed TMDL Project Area in West Virginia

Landuse and land cover estimates were originally obtained from vegetation data gathered from the National Land Cover Dataset (NLCD) (USGS 2011). The Multi-Resolution Land Characteristics Consortium (MRLC) produced the NLCD coverage. The NLCD database for West Virginia was derived from satellite imagery taken during the mid-2000s, and it includes detailed vegetative spatial data. Enhancements and updates to the NLCD coverage were made to create a modeled landuse by custom edits derived primarily from WVDEP source tracking information and 2011 aerial photography with 1-meter resolution. Additional information regarding the NLCD spatial database is provided in **Appendix B** of the Technical Report.

Table 3-1 displays the landuse distribution for the TMDL watersheds that were modeled under this effort. Modeled landuses were derived from NLCD as described above. The dominant landuse is forest, which constitutes 86.2 percent of the total landuse area. Other important modeled landuse types are grassland (4.3 percent), pasture (2.8 percent), Urban/Residential (2.1 percent), wetland (1.4 percent), and barren (1.3 percent). Individually, all other land cover types compose less than one percent of the total watershed area each.

Table 3-1. Modified landuse for the Meadow River TMDL watersheds

Landuse Type	Area of Watershed		
	Acres	Square Miles	Percentage
Barren	2,717.4	4.2	1.3
Cropland	1,095.1	1.7	0.5
Forest	179,073.1	279.8	86.2
Grassland	9,006.8	14.1	4.3
Pasture	5,764.2	9.0	2.8
Paved Road	1,516.6	2.4	0.7
Urban/Residential	4,358.7	6.8	2.1
Riparian Pasture	233.2	0.4	0.1
Water	981.0	1.5	0.5
Wetland	2,890.5	4.5	1.4
Total	**207,636.6**	**324.4**	**100.0**

3.2 Data Inventory

Various sources of data were used in the TMDL development process. The data were used to identify and characterize sources of pollution and to establish the water quality response to those sources. Review of the data included a preliminary assessment of the watershed's physical and socioeconomic characteristics and current monitoring data. **Table 3-2** identifies the data used to support the TMDL assessment and modeling effort. These data describe the physical conditions of the TMDL watersheds, the potential pollutant sources and their contributions, and the impaired waterbodies for which TMDLs need to be developed. Prior to TMDL development, WVDEP collected comprehensive water quality data throughout the watershed. This pre-TMDL monitoring effort contributed the largest amount of water quality data to the process and is summarized in the Technical Report, **Appendix F**. The geographic information is provided in the ArcGIS Viewer Project.

Table 3-2. Datasets used in TMDL development

Type of Information		Data Sources
Watershed physiographic data	Stream network	USGS National Hydrography Dataset (NHD)
	Landuse	National Land Cover Dataset 2011 (NLCD)
	NAIP 2011 Aerial Photography (1-meter resolution)	U.S. Department of Agriculture (USDA)
	Counties	U.S. Census Bureau
	Cities/populated places	U.S. Census Bureau
	Soils	State Soil Geographic Database (STATSGO) USDA, Natural Resources Conservation Service (NRCS) soil surveys (NRCS, 1994)
	Hydrologic Unit Code boundaries	U.S. Geological Survey (USGS)
	Topographic and digital elevation models (DEMs)	National Elevation Dataset (NED)
	Dam locations	USGS
	Roads	2011 U.S. Census Bureau TIGER, WVU WV Roads
	Water quality monitoring station locations	WVDEP, USEPA STORET
	Meteorological station locations	National Oceanic and Atmospheric Administration, National Climatic Data Center (NOAA-NCDC)
	Permitted facility information	WVDEP Division of Water and Waste Management (DWWM), WVDEP Division of Mining and Reclamation (DMR)
	Timber harvest data	WV Division of Forestry
	Oil and gas operations coverage	WVDEP Office of Oil and Gas (OOG)
	Abandoned mining coverage	WVDEP DMR
Monitoring data	Historical Flow Record (daily averages)	USGS
	Rainfall	NOAA-NCDC
	Temperature	NOAA-NCDC
	Wind speed	NOAA-NCDC
	Dew point	NOAA-NCDC
	Humidity	NOAA-NCDC
	Cloud cover	NOAA-NCDC
	Water quality monitoring data	USEPA STORET, WVDEP
	National Pollutant Discharge Elimination System (NPDES) data	WVDEP DMR, WVDEP DWWM

Type of Information		Data Sources
	Discharge Monitoring Report data	WVDEP DMR, Mining Companies
	Abandoned mine land data	WVDEP DMR, WVDEP DWWM
Regulatory or policy information	Applicable water quality standards	WVDEP
	Section 303(d) list of impaired waterbodies	WVDEP, USEPA
	Nonpoint Source Management Plans	WVDEP

3.3 Impaired Waterbodies

WVDEP conducted extensive water quality monitoring throughout the Meadow River Watershed from 2013 through 2014. The results of that effort were used to confirm the impairments of waterbodies identified on previous 303(d) lists and to identify other impaired waterbodies that were not previously listed.

TMDLs were developed for impaired waters in 13 TMDL watersheds (**Figure 3-2**). The impaired waters for which TMDLs have been developed are presented in **Table 3-3**. The table includes the TMDL watershed, stream code, stream name, and impairments for each stream.

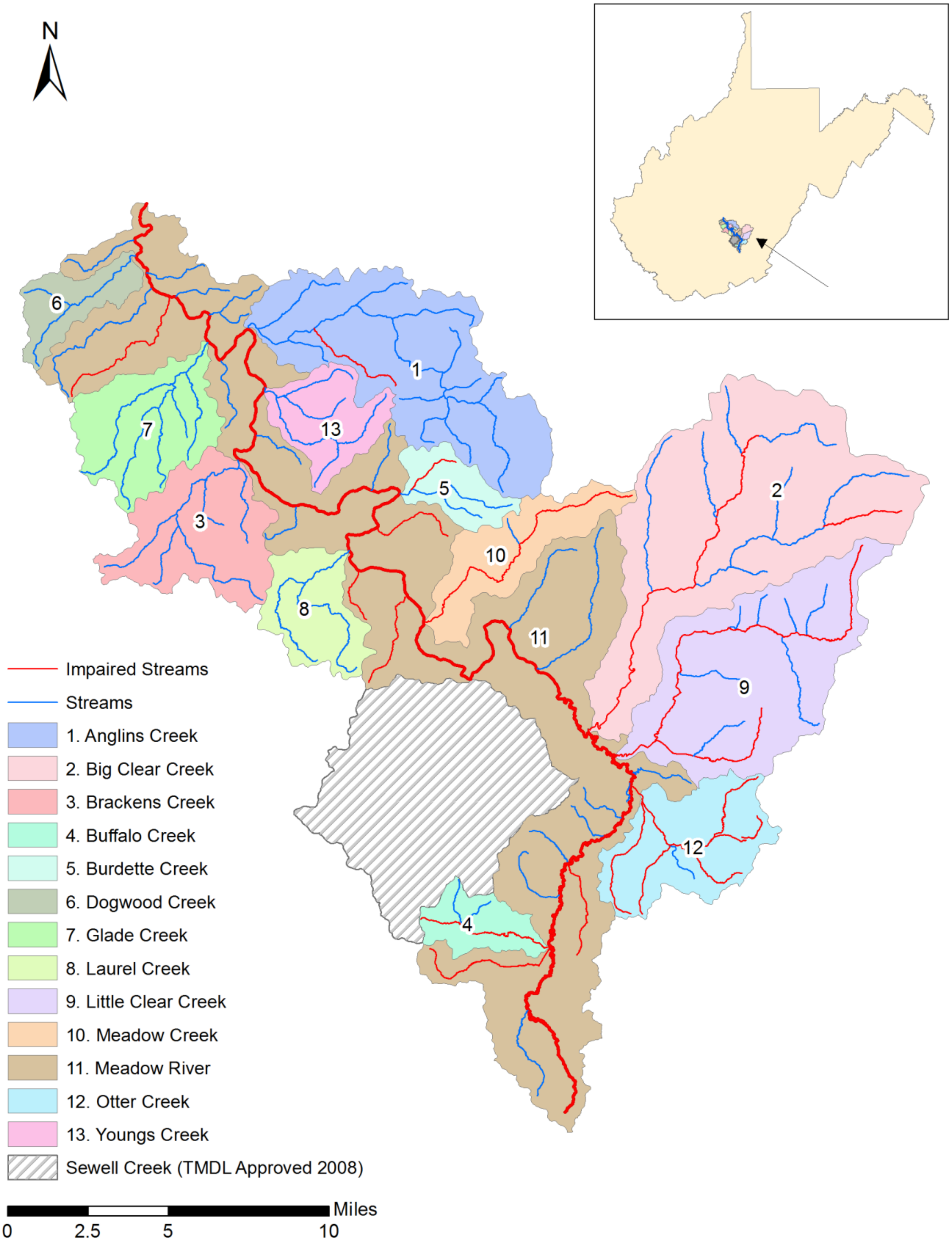

Figure 3-2. Meadow River TMDL Watersheds

Table 3-3. Waterbodies and impairments for which TMDLs have been developed.

Subwatershed	Stream Name	NHD Code	pH	FC
Meadow River	Meadow River	WV-KG-55		X
Burdette Creek	Piney Creek	WV-KG-55-AF-1	X	
Meadow River	Toms Creek	WV-KG-55-AG	X	
Meadow River	Kates Creek	WV-KG-55-AM	X	
Meadow River	Surbaugh Creek	WV-KG-55-AT	X	
Meadow Creek	Meadow Creek	WV-KG-55-AU		X
Big Clear Creek	Big Clear Creek	WV-KG-55-BS		X
Big Clear Creek	Old Field Branch	WV-KG-55-BS-16-G	X	
Little Clear Creek	Little Clear Creek	WV-KG-55-CA		X
Little Clear Creek	Beaver Creek	WV-KG-55-CA-3		X
Otter Creek	Otter Creek	WV-KG-55-CH		X
Otter Creek	UNT/Otter Creek RM 2.81	WV-KG-55-CH-10		X
Otter Creek	UNT/Otter Creek RM 4.03	WV-KG-55-CH-11		X
Otter Creek	Methodist Branch	WV-KG-55-CH-4		X
Otter Creek	Smoot Branch	WV-KG-55-CH-8		X
Meadow River	Callahan Branch	WV-KG-55-CM		X
Buffalo Creek	Buffalo Creek	WV-KG-55-CU		X
Meadow River	Morris Fork	WV-KG-55-CV		X
Meadow River	Arrowwood Creek	WV-KG-55-G	X	
Anglins Creek	Sugargrove Creek	WV-KG-55-N-6	X	

Note:
RM river mile
UNT unnamed tributary
pH acidity impairment
FC fecal coliform bacteria impairment

4.0 pH SOURCE ASSESSMENT

pH impairments in the study area are caused by acidity introduced by acid depostion. WVDEP source tracking and pre-TMDL water quality monitoring were used to determine the causative sources. Those activities did not identify any land-based causative sources of impairment.

4.1 Acid Deposition

Acid rain is produced when atmospheric moisture reacts with gases to form sulfuric acid, nitric acid, and carbonic acid. These gases are primarily formed from nitrogen dioxides and sulfur dioxide, which enter the atmosphere through exhaust and smoke from burning fossil fuels such as gas, oil, and coal. Two-thirds of sulfur dioxides and one-fourth of nitrogen oxides present in the atmosphere are attributed to fossil fuel burning electric power generating plants (USEPA, 2005). Acid rain crosses watershed boundaries and may originate in the Ohio River Valley or the Midwestern United States.

The majority of the acid deposition occurs in the eastern United States. In March 2005, the USEPA issued the Clean Air Interstate Rule (CAIR), which places caps on emissions for sulfur dioxide and nitrogen dioxides for the eastern United States. It was expected that CAIR would reduce sulfur dioxide emissions by over 70 percent and nitrogen oxides emissions by over 60 percent from the 2003 emission levels (USEPA, 2005).

Effective January 1, 2015, CAIR was replaced by the Cross-State Air Pollution Rule (CSAPR). Similar to CAIR, CSAPR also places caps on emissions for sulfur dioxide and nitrogen oxides for the eastern United States. Combined with other final state and EPA actions, CSAPR will reduce power plant SO2 emissions by 73 percent and NOX emissions by 54 percent from 2005 levels in the CSAPR region (USEPA, 2016). Because pollution is highly mobile in the atmosphere, reductions based on CSAPR in West Virginia, Ohio, and Pennsylvania will likely improve the quality of precipitation in the watershed.

Acid deposition occurs by two main methods: wet and dry. Wet deposition occurs through rain, fog, and snow. Dry deposition originates from gases and particles. Dry deposition accounts for approximately half of the atmospheric deposition of acidity (USEPA, 2005). Winds blow the particles and gases contributing to acid deposition over large distances, including political boundaries, such as state boundaries. After dry deposition occurs, particles and gases can be washed into streams from trees, roofs, and other surfaces by precipitation.

Weekly wet deposition data were retrieved from National Atmospheric Deposition Program station WV04-Babcock State Park in Fayette County from 2000 to the most recent data 2014. The Clean Air Status and Trends Network (CASTNET) was accessed to retrieve dry deposition data from CDR119 in Gilmer County.

4.2 pH – Natural Influences

The natural conditions may result in lowered pH levels due to the lack of buffering capacity in soils and certain geologic formations. Acidic soils such as the Pottsville Group, which has very low buffering capacity, is a dominant or co-dominant soil type in several pH impaired watersheds in the Meadow River basin. Other watersheds have other acidic soil types that would result in low buffering capacity.

Within the soils, soil parameters such as base saturation, cation exchange capacity, dissolution susceptibility of aluminum minerals (aluminum hydroxides), and soil CO2 control acidification of soils and the land outflows. The heterogeneous nature of these parameters result in different buffering capacities for different soil types. Thus, different soil types in subwatersheds were assumed to react differently to the acidity from atmospheric deposition.

Additionally, natural conditions such as wetlands/bogs reduce the pH levels and buffering capacity downstream. Bogs receive most of their water from precipitation, which is naturally acidic, and pH may be decreased from the natural decomposition of organic materials (MDE 2003).

4.3 Alkalinity Sources

Although the buffering capacity provided by underlying geology within the watershed is limited, soils with moderate buffering capacity such as skeletal loamy residuum weathered from sandstone and shale, and also colluvium derived from sandstone and siltstone, could be a source of alkalinity in some modeled subwatersheds. Dissolution of carbonate rocks neutralizes the excessive acidity from atmospheric precipitation and provides natural loading of alkalinity to the streams. As a result, near neutral pH levels are commonly observed in the streams from geologic formations of carbonate rocks.

To restore water quality and protect fisheries in streams affected by acid deposition, selected acidic streams in the Meadow River Watershed are treated with instream applications of fine-grained limestone. The location of liming stations and dosages in the Meadow River Watershed were provided by the WVDEP and included data recorded by the West Virginia Division of Natural Resources. The applied dosage information for these remediation methods were included for calibration purposes.

5.0 FECAL COLIFORM SOURCE ASSESSMENT

5.1 Fecal Coliform Point Sources

Publicly and privately owned sewage treatment facilities and home aeration units are point sources of fecal coliform bacteria. Combined sewer overflows (CSOs) and discharges from MS4s are additional point sources that may contribute loadings of fecal coliform bacteria to receiving streams. The following sections discuss the specific types of fecal coliform point sources that were identified in the Meadow River Watershed.

5.1.1 Individual NPDES Permits

WVDEP issues individual NPDES permits to both publicly owned and privately owned wastewater treatment facilities. Publicly owned treatment works (POTWs) are relatively large sewage treatment facilities with extensive wastewater collection systems, whereas private facilities are usually used in smaller applications such as subdivisions and shopping centers. Additionally specific discharges from industrial facilities are regulated for fecal coliform bacteria.

In the subject watersheds of this report, there are 3 individually permitted sewage treatment facilities associated with mining bathhouses that discharge to impaired streams via 3 outlets. These sources are regulated by NPDES permits that require effluent disinfection and compliance with strict fecal coliform effluent limitations (200 counts/100 mL [geometric mean monthly] and 400 counts/100 mL [maximum daily]). Compliant facilities do not cause fecal coliform bacteria impairments because effluent limitations are more stringent than water quality criteria. There are no other individually permitted sewage treatment facilities.

5.1.2 Overflows

CSOs are outfalls from POTW sewer systems that discharge untreated domestic waste and surface runoff. CSOs are permitted to discharge only during precipitation events. Sanitary sewer overflows (SSOs) are unpermitted overflows that occur as a result of excess inflow and/or infiltration to POTW separate sanitary collection systems. Both types of overflows contain fecal coliform bacteria.

In the subject watersheds of this report, no CSO discharges were present, and no SSO discharges were represented in the model.

5.1.3 Municipal Separate Storm Sewer Systems (MS4)

Runoff from residential and urbanized areas during storm events can be a significant fecal coliform source. USEPA's stormwater permitting regulations require public entities to obtain NPDES permit coverage for stormwater discharges from MS4s in specified urbanized areas. As such, MS4 stormwater discharges are considered point sources and are prescribed WLAs.

Because the Meadow River watershed is predominantly rural, there were no MS4s in the subject watersheds of this report.

5.1.4 General Sewage Permits

General sewage permits are designed to cover like discharges from numerous individual owners and facilities throughout the state. General Permit WV0103110 regulates small, privately owned sewage treatment plants ("package plants") that have a design flow of 50,000 gallons per day (GPD) or less. General Permit WV0107000 regulates home aeration units (HAUs). HAUs are small sewage treatment plants primarily used by individual residences where site considerations preclude typical septic tank and leach field installation. Both general permits contain fecal coliform effluent limitations identical to those in individual NPDES permits for sewage treatment facilities. Compliant facilities do not cause fecal coliform bacteria impairments because effluent limitations are more stringent than water quality criteria. In the areas draining to streams for which fecal coliform TMDLs have been developed, 6 facilities are registered under the “package plant” general permit. There were no facilities registered under the HAU general permit in subject watersheds of this report.

5.2 Fecal Coliform Nonpoint Sources

5.2.1 On-site Treatment Systems

Failing septic systems and straight pipes are significant nonpoint sources of fecal coliform bacteria. Information collected during source tracking efforts by WVDEP yielded an estimate of 1047 homes that are not served by centralized sewage collection and treatment systems and are within 100 meters of a stream. Homes located more than 100 meters from a stream were not considered significant potential sources of fecal coliform because of the natural attenuation of fecal coliform concentrations that occurs because of bacterial die-off during overland travel (Walsh and Kunapo, 2009). Estimated septic system failure rates across the watershed range from 3 percent to 28 percent.

Due to a wide range of available literature values relating to the bacteria loading associated with failing septic systems, a customized Microsoft Excel spreadsheet tool was created to represent the fecal coliform bacteria contribution from failing on-site septic systems. WVDEP’s pre-TMDL monitoring and source tracking data were used in the calculations. To calculate loads, values for both wastewater flow and fecal coliform concentration are needed.

To calculate failing septic wastewater flows, the TMDL watersheds were divided into four septic failure zones. During the WVDEP source tracking process, septic failure zones were delineated by soil characteristics (soil permeability, depth to bedrock, depth to groundwater and drainage capacity) as shown in United States Department of Agriculture (USDA) county soil survey maps. Two types of failure were considered, complete failure and periodic failure. For the purposes of this analysis, complete failure was defined as 50 gallons per house per day of untreated sewage escaping a septic system as overland flow to receiving waters and periodic failure was defined as 25 gallons per house per day. **Figure 5-1** shows the fecal coliform counts per year represented in the model from failing septic systems relative to the total stream length in meters for each subwatershed.

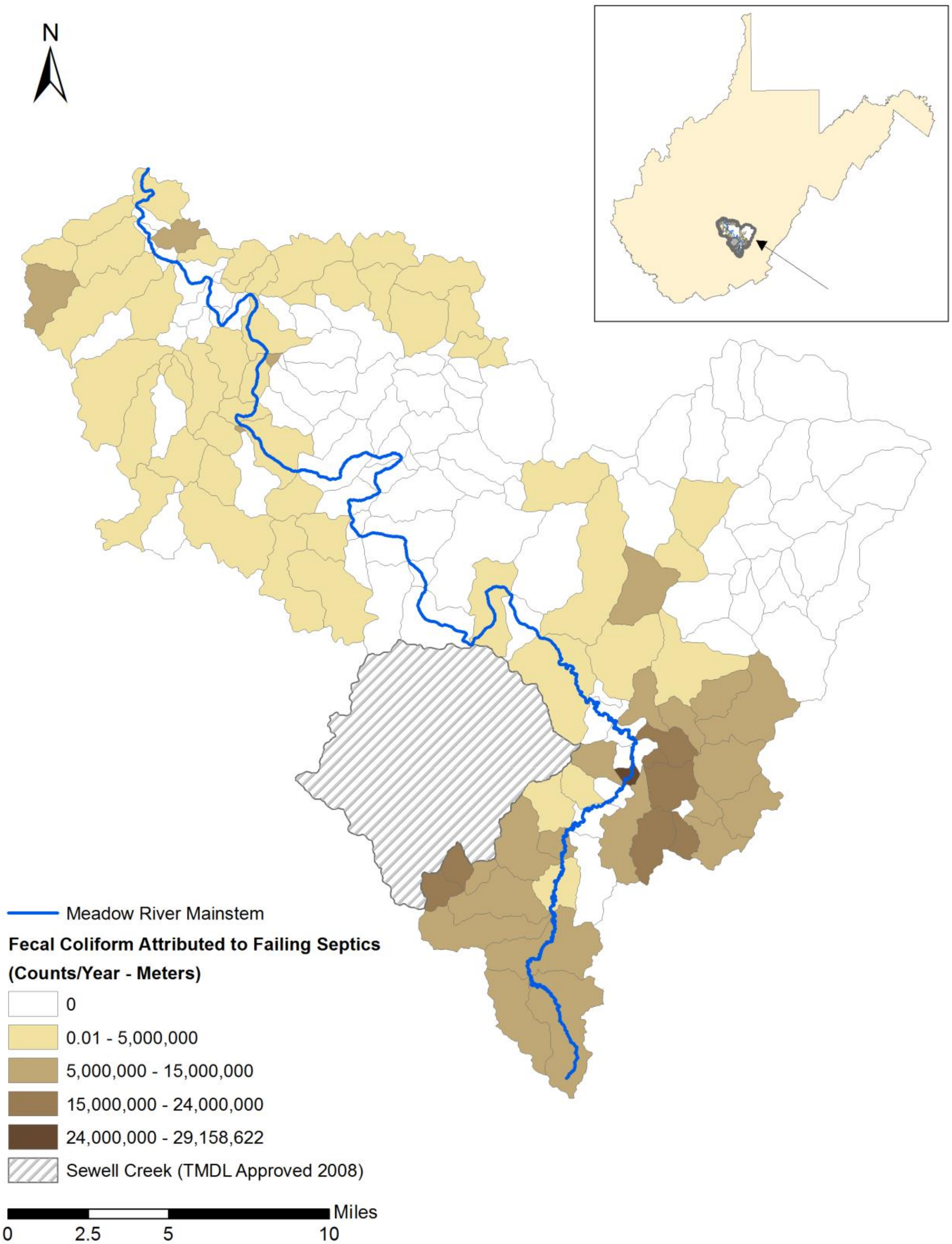

Figure 5-1. Fecal coliform counts attributed to failing septic systems per year relative to the stream lengths (meters) in the Meadow River Watershed as represented in modeling.

Once failing septic flows were modeled, a fecal coliform concentration was determined at the TMDL watershed scale. Based on past experience with other West Virginia TMDLs, a base concentration of 10,000 counts per 100 ml was used as a beginning concentration for failing septic systems. This concentration was further refined during model calibration. A sensitivity analysis was performed by varying the modeled failing septic concentrations in multiple model runs, and then comparing model output to pre-TMDL monitoring data. Additional details of the failing septic analyses are provided in the Technical Report.

For the purposes of this TMDL, discharges from activities that do not have an associated NPDES permit, such as failing septic systems and straight pipes, are considered nonpoint sources. The decision to assign LAs to those sources does not reflect a determination by WVDEP or USEPA as to whether they are, in fact, non-permitted point source discharges. Likewise, by establishing these TMDLs with failing septic systems and straight pipes treated as nonpoint sources, WVDEP and USEPA are not determining that such discharges are exempt from NPDES permitting requirements.

5.2.2 Urban/Residential Runoff

Stormwater runoff from residential and urbanized areas that are not subject to MS4 permitting requirements can be a significant source of fecal coliform bacteria. These landuses are considered to be nonpoint sources and load allocations are prescribed. The modified NLCD 2011 landuse data were used to determine the extent of residential and urban areas not subject to MS4 permitting requirements and source representation was based upon precipitation and runoff.

5.2.3 Agriculture

Agricultural activities can contribute fecal coliform bacteria to receiving streams through surface runoff or direct deposition. Grazing livestock and land application of manure result in the deposition and accumulation of bacteria on land surfaces. These bacteria are then available for wash-off and transport during rain events. In addition, livestock with unrestricted access can deposit feces directly into streams.

Although agricultural activity accounts for a small percentage of the overall watershed, agriculture is a significant localized nonpoint source of fecal coliform bacteria. Source tracking efforts identified pastures and feedlots near impaired segments that have localized impacts on instream bacteria levels. Source representation was based upon precipitation and runoff, and source tracking information regarding number of livestock, proximity and access to stream, estimated riparian pasture areas, and overall runoff potential were used to develop accumulation rates.

5.2.4 Natural Background (Wildlife)

A certain “natural background” contribution of fecal coliform bacteria can be attributed to deposition by wildlife in forested areas. Accumulation rates for fecal coliform bacteria in forested areas were developed using reference numbers from past TMDLs, incorporating wildlife estimates obtained from West Virginia’s Division of Natural Resources (WVDNR). In addition, WVDEP conducted storm-sampling on a 100 percent forested subwatershed (Shrewsbury

Hollow) within the Kanawha State Forest, Kanawha County, West Virginia to determine wildlife contributions of fecal coliform. These results were used during the model calibration process. On the basis of the low fecal accumulation rates for forested areas, the storm water sampling results, and model simulations, wildlife is not considered to be a significant nonpoint source of fecal coliform bacteria in the watershed.

6.0 MODELING PROCESS

Establishing the relationship between the instream water quality targets and source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses with flow and loading conditions. This section presents the approach taken to develop the linkage between sources and instream response for TMDL development in the Meadow River Watershed.

6.1 Model Selection

Selection of the appropriate analytical technique for TMDL development was based on an evaluation of technical and regulatory criteria. The following key technical factors were considered in the selection process:

- Scale of analysis
- Point and nonpoint sources
- Fecal coliform bacteria impairments are temporally variable and occur at low, average, and high flow conditions
- Time-variable aspects of land practices have a large effect on instream pollutant concentrations
- Pollutant transport mechanisms are variable and often weather-dependent

The primary regulatory factor that influenced the selection process was West Virginia's water quality criteria. According to 40 CFR Part 130, TMDLs must be designed to implement applicable water quality standards. The applicable water quality criteria for pH and fecal coliform bacteria in West Virginia are presented in **Section 2.2**, **Table 2-1**. West Virginia numeric water quality criteria are applicable at all stream flows greater than the 7-day, 10-year low flow (7Q10). The approach or modeling technique must permit representation of instream concentrations under a variety of flow conditions to evaluate critical flow periods for comparison with criteria.

The TMDL development approach must also consider the dominant processes affecting pollutant loadings and instream fate. In the Meadow River Watershed, point and nonpoint sources contribute to the fecal coliform impairments. Most nonpoint sources are rainfall-driven with pollutant loadings primarily related to surface runoff, but some, such as inadequate onsite residential sewage treatment systems, function as continuous discharges. Similarly, certain point sources are precipitation-induced while others are continuous discharges. While loading function variations must be recognized in the representation of the various sources, the TMDL allocation process must prescribe WLAs for all contributing point sources and LAs for all contributing nonpoint sources.

The MDAS was developed specifically for TMDL application in West Virginia to facilitate large scale, data intensive watershed modeling applications. The MDAS is a system designed to support TMDL development for areas affected by nonpoint and point sources. The MDAS component most critical to TMDL development is the dynamic watershed model because it provides the linkage between source contributions and instream response. The MDAS is used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and instream water quality. It is capable of simulating different flow regimes and pollutant loading variations. A key advantage of the MDAS' development framework is that it has no inherent limitations in terms of modeling size or upper limit of model operations. In addition, the MDAS allows for seamless integration with modern-day, widely available software such as Microsoft Access and Excel. pH and fecal coliform bacteria were modeled using the MDAS.

6.2 Model Setup

Model setup consisted of configuring two separate MDAS models for pH and fecal coliform bacteria.

6.2.1 General MDAS Configuration

Configuration of the MDAS model involved subdividing the TMDL watersheds into subwatershed modeling units connected by stream reaches. Physical characteristics of the subwatersheds, weather data, landuse information, continuous discharges, and stream data were used as input. Flow and water quality were continuously simulated on an hourly time-step.

Two grid-based weather data products were used to develop MDAS model weather input files for TMDL modeling. The Parameter-Elevation Regressions on Independent Slopes Model (PRISM) and the North American Land Data Assimilation System (NLDAS-2) are both publicly available weather datasets. PRISM data features daily weather on 4 km grid spatial scale, and NLDAS-2 data has hourly weather on a 12 km grid scale. Both datasets combine rain gauge data with radar observations to predict hourly weather parameters such as precipitation, solar radiation, wind, and humidity. For more information on PRISM and NLDAS-2, refer to Section 2 of the Technical Report.

PRISM daily weather data and NLDAS-2 hourly precipitation data were obtained and processed to create a time series for each PRISM grid cell that contained modeled TMDL watersheds. Using the precipitation and temperature time series, a model weather input file was developed for each PRISM grid cell. Given that only slight variability was observed between the grid cells at the 12-digit Hydrologic Unit Code (HUC) scale, and to allow for faster model run times, one centrally located weather input file per each of the nine 12-digit HUCs in the Meadow River Watershed was identified as representative of the weather in the area. Model subwatersheds falling within each 12-digit HUC were then assigned the appropriate weather input file for hydrologic modeling purposes.

The 13 TMDL watersheds were broken into 170 separate subwatershed units, based on the groupings of impaired streams shown in **Figure 3-2**. The TMDL watersheds were divided to allow evaluation of water quality and flow at pre-TMDL monitoring stations. This subdivision process also ensures a proper stream network configuration within the basin.

6.2.3 pH Configuration

The MDAS model includes a dynamic chemical species fate and transport module that simulates soil subsurface and in-stream water quality taking into account chemical species interaction and transformation. The time series for total chemical concentration and flows generated by MDAS are used as inputs for the modules' pollutant transformation and transport routines. The modules simulate soil subsurface and in-stream chemical reactions, assuming instant mixing and concentrations equally distributed throughout soil and stream segments. The model supports major chemical reactions, including acid/base, complexation, precipitation, and dissolution reactions and some kinetic reactions. The model selection process, modeling methodologies, and technical approaches are discussed further in the Technical Report.

Pollutant Source Configuration

In order to represent the effects of acid precipitation, soil type parameters were selected using the literature and refined based on site data ranges. The concentrations of the wet deposition data were assigned to rainfall events. The dry deposition was assumed to accumulate daily and wash off during the precipitation events and was assumed to be included implicitly in the loads being generated at the surface. Wet deposition data were retrieved from the closest National Atmospheric Deposition Program station, WV04-Babcock State Park in Fayette County, for the time period 2000 to 2014. The Clean Air Status and Trends Network (CASTNET) was accessed to retrieve weekly dry deposition data from the nearest dry deposition station, CDR119 in Gilmer County. Concentrations of the wet deposition data were assigned to rainfall events. Dry deposition was assumed to accumulate over time, and then wash off during rainfall events. Adjustment and verification of these parameters was performed by examining water quality data in streams where watersheds did not include confounding factors such as discharges or alkalinity additions from limestone dosing. Relationships between atmospheric deposition and soil buffering capacity were also identified using these watersheds.

Instream Chemical Reaction

Wet and dry atmospheric deposition inputs were discharged to the stream via the hydrologic functions of the model. All added loadings were subjected to subsequent instream chemical reactions. The important factors influencing instream pH in acid deposition watersheds are:

- The presence of acidic soils in the watershed
- Size of the watershed
- Stream buffering capacity

During model calibration, it was identified that the instream low pH conditions were influenced by acidic soils with low cation exchange capacity, the hydrologic characteristics of small headwater watersheds that shorten water contact time with potential neutralizing agents, and the overall buffering capacity of the stream. Also, the presence of organic acids in some watershed soils intensified acidic conditions in streams.

6.2.4 Fecal Coliform Configuration

Modeled landuse categories contributing bacteria via precipitation and runoff include pasture, cropland, urban/residential pervious lands, urban/residential impervious lands, grassland, forest, barren land, and wetlands. Other sources, such as failing septic systems, straight pipes, and discharges from sewage treatment facilities, were modeled as direct, continuous-flow sources.

The basis for the initial bacteria loading rates for landuses and direct sources is described in the Technical Report. The initial estimates were further refined during the model calibration. A variety of modeling tools were used to develop the fecal coliform bacteria TMDLs, including the MDAS, and a customized spreadsheet to determine the fecal loading from failing residential septic systems identified during source tracking efforts by the WVDEP. **Section 5.2.1** describes the process of assigning flow and fecal coliform concentrations to failing septic systems.

6.3 Hydrology Calibration

Hydrology and water quality calibration were performed in sequence because water quality modeling is dependent on an accurate hydrology simulation. Typically, hydrology calibration involves a comparison of model results with instream flow observations from USGS flow gauging stations throughout the watershed. One USGS gauging station located in the Meadow River watershed had adequate data records for model hydrology calibration: USGS 03190000 Meadow River At Nallen, WV.

Hydrology calibration compared observed data from the stations and modeled runoff from the landuses present in the watershed. Key considerations for hydrology calibration included the overall water balance, the high- and low-flow distribution, storm flows, and seasonal variation. The hydrology was validated for the time period of October 1, 2012 to October 30, 2013. As a starting point, many of the hydrology calibration parameters originated from the USGS Scientific Investigations Report 2005-5099 (Atkins, 2005). Final adjustments to model hydrology were based on flow measurements obtained during WVDEP's pre-TMDL monitoring in the Meadow River Watershed. A detailed description of the hydrology calibration and a summary of the results and validation are presented in the Technical Report in **Appendix E**.

6.4 Water Quality Calibration

After the model was configured and calibrated for hydrology, the next step was to perform water quality calibration for the subject pollutants. The goal of water quality calibration was to refine model parameter values to reflect the unique characteristics of the watershed so that model output would predict field conditions as closely as possible. Both spatial and temporal aspects were evaluated through the calibration process.

The water quality was calibrated by comparing modeled versus observed pollutant concentrations. The water quality calibration consisted of executing the MDAS model, comparing the model results to available observations, and adjusting water quality parameters within reasonable ranges. Initial model parameters for the various pollutant parameters were derived from previous West Virginia TMDL studies, storm sampling efforts, and literature values. Available monitoring data in the watershed were identified and assessed for application to calibration. Monitoring stations with observations that represented a range of hydrologic conditions, source types, and pollutants were selected. The time-period for water quality calibration was selected based on the availability of the observed data and their relevance to the current conditions in the watershed.

WVDEP also conducted storm monitoring on Shrewsbury Hollow in Kanawha State Forest, Kanawha County, West Virginia. The data gathered during this sampling episode was used in the calibration of fecal coliform and to enhance the representation of background conditions from undisturbed areas. The results of the storm sampling fecal coliform calibration are shown in **Figure 6-1**.

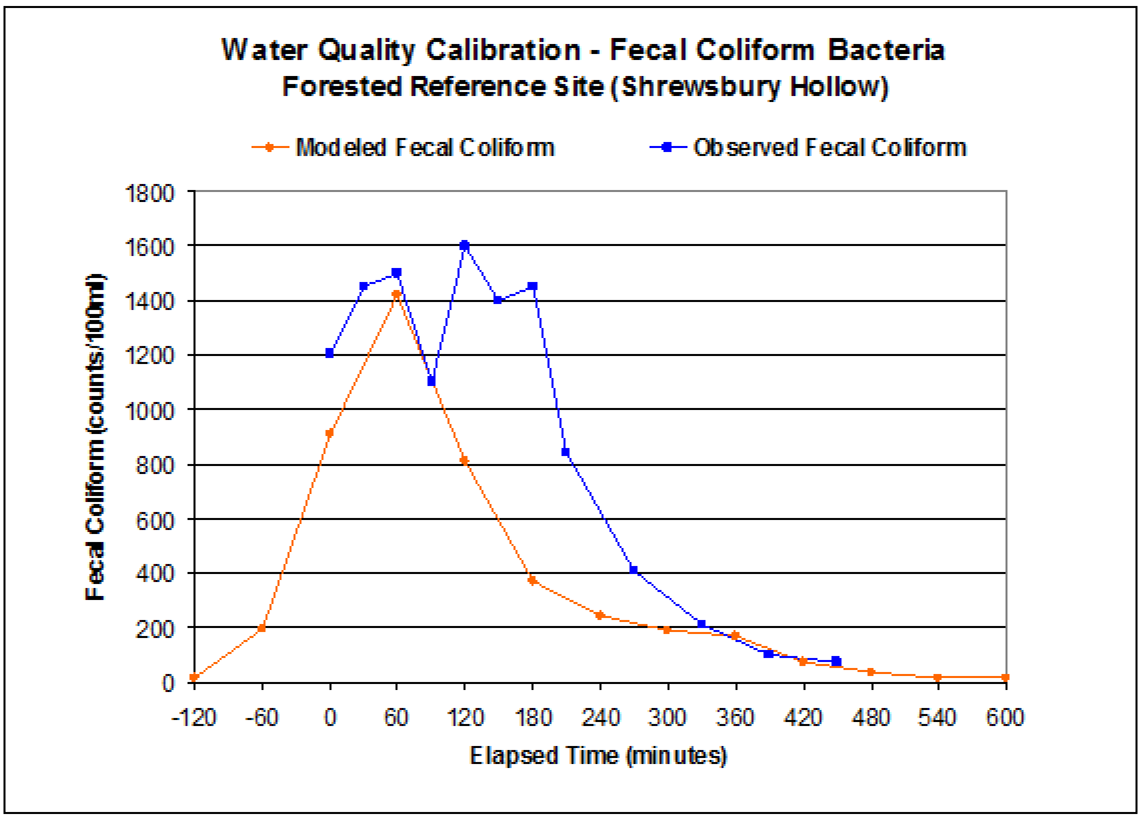

Figure 6-1. Shrewsbury Hollow fecal coliform observed data

6.6 Allocation Strategy

As explained in **Section 2**, a TMDL is composed of the sum of individual WLAs for point sources, LAs for nonpoint sources, and natural background levels. In addition, the TMDL must include a MOS, implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. TMDLs can be expressed in terms of mass per time or other appropriate units. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \text{sum of WLAs} + \text{sum of LAs} + \text{MOS}$$

To develop the TMDLs for each of the impairments listed in **Table 3-3** of this report, the following approach was taken:

- Define TMDL endpoints
- Simulate baseline conditions
- Assess source loading alternatives
- Determine the TMDL and source allocations

6.6.1 TMDL Endpoints

TMDL endpoints represent the water quality targets used to quantify TMDLs and their individual components. In general, West Virginia's numeric water quality criteria for the subject pollutants and an explicit five percent MOS were used to identify endpoints for TMDL development. The TMDL endpoints for the various criteria are displayed in **Table 6-1**.

The five percent explicit MOS was used to counter uncertainty in the modeling process. Long-term water quality monitoring data were used for model calibration. Although these data represented actual conditions, they were not of a continuous time series and might not have captured the full range of instream conditions that occurred during the simulation period.

Table 6-1. TMDL endpoints

Water Quality Criterion	Designated Use	Criterion Value	TMDL Endpoint
pH	Aquatic Life	6.00 Standard Units (Minimum)	6.02 Standard Units (Minimum)
Fecal Coliform	Water Contact Recreation and Public Water Supply	200 counts / 100 mL (Monthly Geometric Mean)	190 counts / 100 mL (Monthly Geometric Mean)
Fecal Coliform	Water Contact Recreation and Public Water Supply	400 counts / 100 mL (Daily, 10% exceedance)	380 counts / 100 mL (Daily, 10% exceedance)

TMDLs are presented as average daily loads that were developed to meet TMDL endpoints under a range of conditions observed throughout the year. For most pollutants, analysis of available data indicated that critical conditions occur during both high- and low-flow events. To appropriately address the low- and high-flow critical conditions, the TMDLs were developed using continuous simulation (modeling over a period of several years that captured precipitation extremes), which inherently considers seasonal hydrologic and source loading variability.

6.6.2 Baseline Conditions and Source Loading Alternatives

The calibrated model provides the basis for performing the allocation analysis. The first step is to simulate baseline conditions, which represent existing nonpoint source loadings and point sources loadings at permit limits. Baseline conditions allow for an evaluation of instream water quality under the highest expected loading conditions.

Baseline Conditions for MDAS

The MDAS model was run for baseline conditions using hourly precipitation data for a representative six year simulation period (January 1, 2008 through December 31, 2013). The precipitation experienced over this period was applied to the landuses and pollutant sources as they existed at the time of TMDL development. Predicted instream concentrations were compared directly with the TMDL endpoints. This comparison allowed for the evaluation of the magnitude and frequency of exceedances under a range of hydrologic and environmental conditions, including dry periods, wet periods, and average periods. The observed precipitation for the years 2004 through 2014 at the Raleigh County Memorial Airport (WBAN 03872) weather station in West Virginia is shown in **Figure 6-2.** The years 2008 to 2013 are highlighted to indicate the range of precipitation conditions used for TMDL development in the Meadow River Watershed.

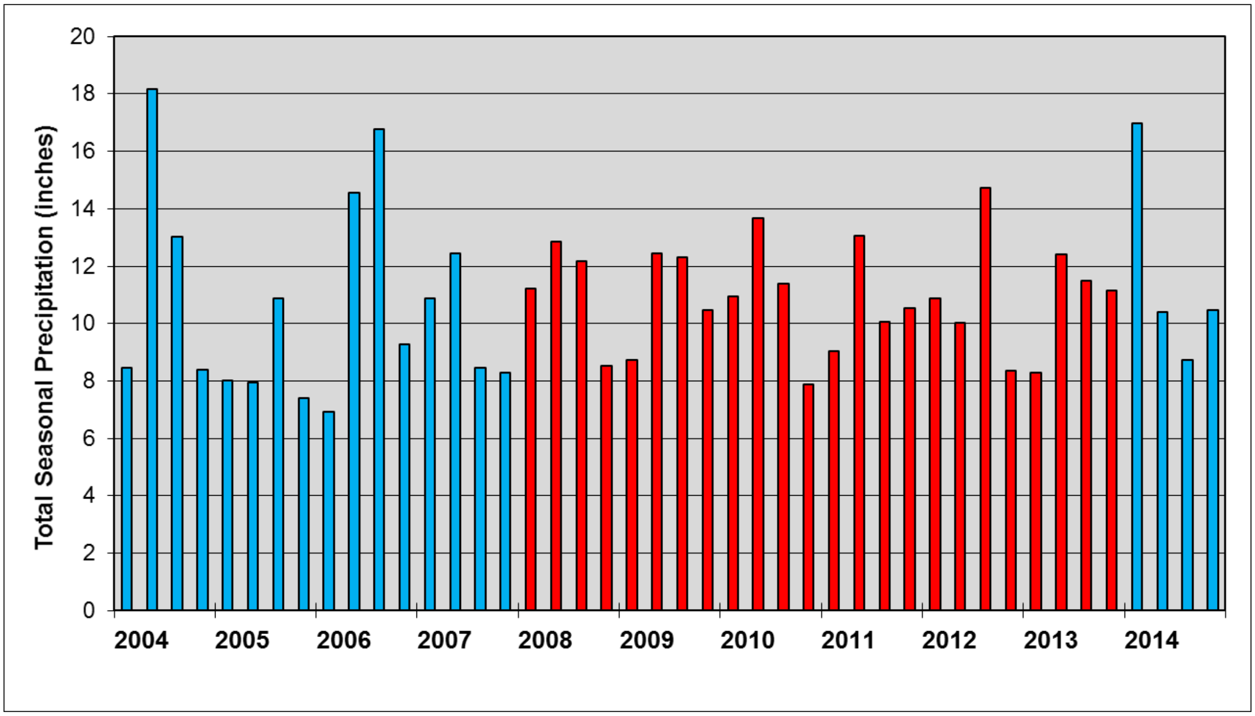

Figure 6-2. Seasonal precipitation totals for the Raleigh County Memorial Airport (WBAN 03872) weather station

Effluents from sewage treatment plants were represented under baseline conditions as continuous discharges, using the design flow for each facility and the monthly geometric mean fecal coliform effluent limitation of 200 counts/100 mL.

Source Loading Alternatives

Simulating baseline conditions allowed for the evaluation of each stream's response to variations in source contributions under a variety of hydrologic conditions. This sensitivity analysis gave insight into the dominant sources and the mechanisms by which potential decreases in loads would affect instream pollutant concentrations. The loading contributions from the various existing sources were individually adjusted; the modeled instream concentrations were then evaluated.

Multiple allocation scenarios were run for the impaired waterbodies. Successful scenarios achieved the TMDL endpoints under all flow conditions throughout the modeling period. The averaging period and allowable exceedance frequency associated with West Virginia water quality criteria were considered in these assessments. In general, loads contributed by sources that had the greatest impact on instream concentrations were reduced first. If additional load reductions were required to meet the TMDL endpoints, less significant source contributions were subsequently reduced.

Figure 6-3 shows an example of model output for a baseline condition and a successful TMDL scenario.

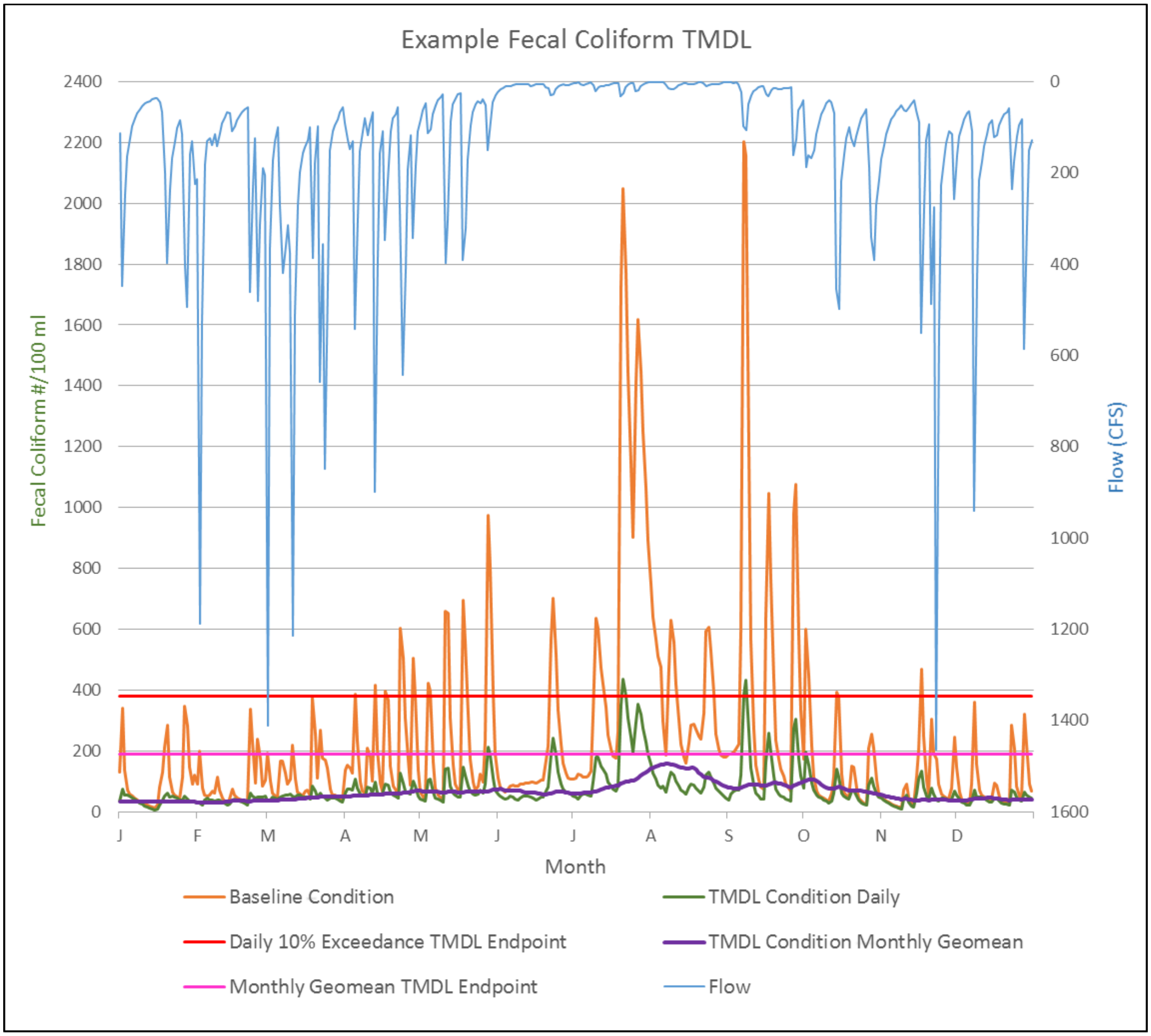

Figure 6-3. Example of baseline and TMDL conditions for fecal coliform

6.7 TMDLs and Source Allocations

6.7.1 pH TMDLs

Allocation scenarios modeled the addition of an acid neutralizing agent to improve instream water quality conditions and meet the West Virginia pH criterion. Limestone was selected as the neutralizing agent. In watersheds with limestone dosing already occurring, any alkaline materials added to the model for calibration purposes were returned to zero during allocation scenario runs in order to recalculate the necessary dose to achieve the pH target in the watershed.

In order to determine an appropriate allocation period, the atmospheric deposition data (WV04-Babcock State Park) were examined. Due to the noted increase in pH and reduction in sulfate conditions in wet deposition data after 2009 (**Figures 6-4 and 6-5**), the allocation period was selected to be from 2010 through 2014. This five year period was considered to be more reflective of current atmospheric deposition conditions compared to years prior to 2010.

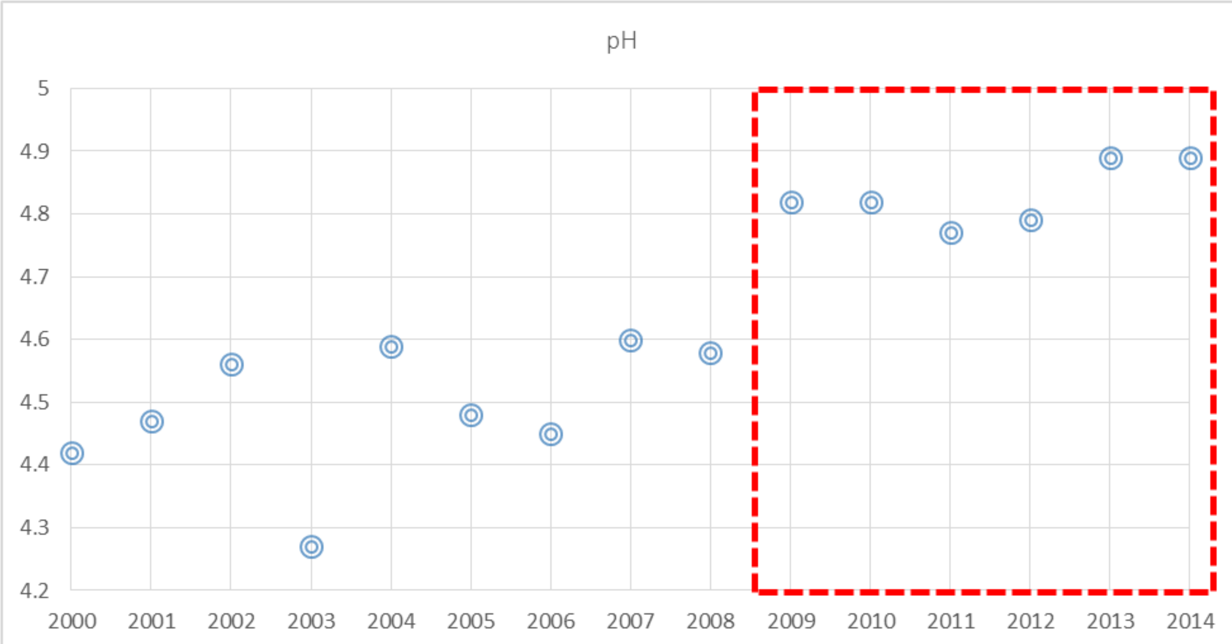

Figure 6-4. Average Annual Wet Deposition pH

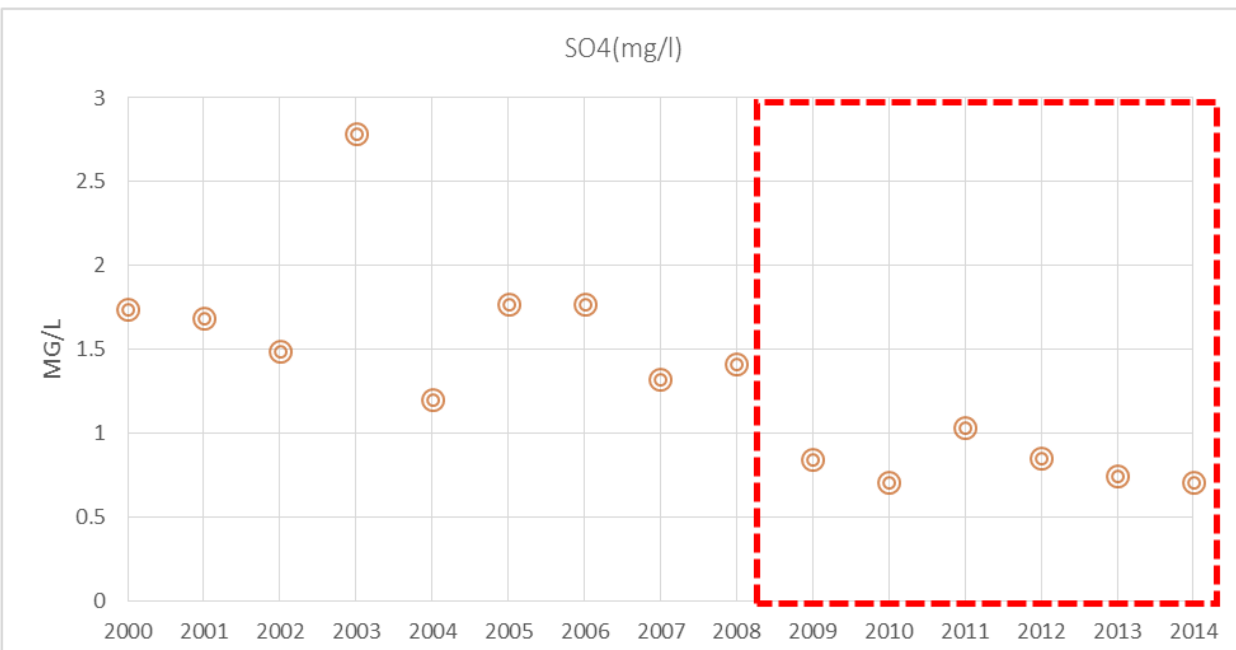

Figure 6-5. Average Annual Sulfate Wet Deposition

Source allocations were developed for all modeled subwatersheds contributing to pH impaired streams of the Meadow River Watershed. The allocation approach focused on increasing pH by assigning buffering capacity using the MDAS model to verify that the resultant pH under these conditions would be in compliance with pH criteria. The assigned buffering capacity or alkalinity was measure in tons per year of calcium carbonate, assuming 100% neutralizing efficiency. The efficiency of a neutralizing agent is dependent on purity and dissolution characteristics. Thus the required tonnage of field applied calcium carbonate will likely be greater than prescribed (particularly for initial doses) to achieve pH criteria.

Load Allocations (LAs)

Load allocation in terms of alkalinity addition are prescribed for each model subwatershed for each impaired stream. These are effective loadings and field applications of acid neutralizing agents should adjusted to compensate for purity and dissolution characteristics.

The alkalinity additions associated with existing fine-grained limestone application in the watershed by the WVDNR were considered in model calibration but were not represented in baseline or allocated conditions because continued operation is not legally mandated. Although these restoration activities are currently resulting in partial or full attainment of TMDL allocations, cessation of operation will result in non-attainment conditions evidenced by upstream monitoring results.

6.7.3 Fecal Coliform Bacteria TMDLs

TMDLs and source allocations were developed for impaired streams and their tributaries on a subwatershed basis throughout the watershed. The following general methodology was used when allocating loads to fecal coliform bacteria sources:

- The effluents from all NPDES permitted sewage treatment plants were set at the permit limit (200 counts/100 mL monthly geometric mean)
- Because West Virginia Bureau for Public Health regulations prohibit the discharge of raw sewage into surface waters, all illicit discharges of human waste (from failing septic systems and straight pipes) were reduced by 100 percent in the model
- If further reduction was necessary, non-point source loadings from agricultural lands and residential areas were subsequently reduced until in-stream water quality criteria were met

Wasteload Allocations (WLAs)

WLAs were developed for all facilities permitted to discharge fecal coliform bacteria as described below.

Sewage Treatment Plant Effluents

The fecal coliform effluent limitations for NPDES permitted sewage treatment plants are more stringent than water quality criteria; therefore, all effluent discharges from sewage treatment facilities were given WLAs equal to existing monthly fecal coliform effluent limitations of 200 counts/100 mL.

Load Allocations (LAs)

Fecal coliform LAs are assigned to the following source categories:

- Pasture/Cropland
- On-site Sewage Systems — loading from all illicit discharges of human waste (including failing septic systems and straight pipes)
- Residential — loading associated with urban/residential runoff from non-MS4 areas
- Background and Other Nonpoint Sources — loading associated with wildlife sources from all other landuses (contributions/loadings from wildlife sources were not reduced)

6.7.4 Seasonal Variation

Seasonal variation was considered in the formulation of the modeling analysis. Continuous simulation (modeling over a period of several years that captured precipitation extremes) inherently considers seasonal hydrologic and source loading variability**.** The pollutant concentrations simulated on a daily time step by the model were compared with TMDL endpoints. Allocations that met these endpoints throughout the modeling period were developed.

6.7.5 Critical Conditions

A critical condition represents a scenario where water quality criteria are most susceptible to violation. Analysis of water quality data for the impaired streams addressed in this effort shows high pollutant concentrations during both high- and low-flow thereby precluding selection of a single critical condition. Both high-flow and low-flow periods were taken into account during TMDL development by using a long period of weather data that represented wet, dry, and average flow periods.

Most nonpoint source loading is typically precipitation-driven and impacts tend to occur during wet weather and high surface runoff. During dry periods little or no land-based runoff occurs, and elevated instream pollutant levels may be due to point sources (Novotny and Olem, 1994). However, some nonpoint sources, such as inadequate onsite residential sewage treatment systems, function as continuous discharges with more severe impacts during low-flow periods. Loading function variations are recognized in the TMDL allocation process that prescribes WLAs for all contributing point sources and LAs for all contributing nonpoint sources that achieve water quality standards over a range of flow conditions.

6.7.6 TMDL Presentation

The TMDLs for all impairments are shown in **Section 7** of this report. The pH TMDLs are presented as average daily loads of net acidity, in pounds per day. The TMDLs for fecal coliform bacteria are presented in average number of colonies per day. All TMDLs were developed to meet TMDL endpoints under a range of conditions observed over the modeling period. TMDLs and their components are also presented in the allocation spreadsheets associated with this report. The filterable spreadsheets also display detailed source allocations and include multiple display formats that allow comparison of pollutant loadings among categories and facilitate implementation.

pH LAs are presented as annual average acidity loads (tons per year) at the subwatershed scale. The fecal coliform bacteria LAs are presented as annual average loads. The fecal coliform bacteria WLAs for sewage treatment plant effluents are presented both as annual average loads, for comparison with other pollutant sources, and equivalent allocation concentrations. The prescribed concentrations are the operable allocations for NPDES permit implementation.

7.0 TMDL RESULTS

Table 7-1. pH TMDLs

TMDL Watershed	Stream Code	Stream Name	LA Average Daily Net Acidity Load (lbs as CaCO3/day)	WLA Average Daily Net Acidity Load (lbs as CaCO3/day)	MOS Average Daily Net Acidity Load (lbs as CaCO3/day)	TMDL Average Daily Net Acidity Load (lbs as CaCO3/day)
Meadow River	WV-KG-55-G	Arrowwood Creek	-78.90	0.00	-4.15	-83.06
Anglins Creek	WV-KG-55-N-6	Sugargrove Creek	-47.67	0.00	-2.51	-50.18
Burdette Creek	WV-KG-55-AF-1	Piney Creek	-61.37	0.00	-3.23	-64.60
Meadow River	WV-KG-55-AG	Toms Creek	-43.84	0.00	-2.31	-46.14
Meadow River	WV-KG-55-AM	Kates Creek	-36.16	0.00	-1.90	-38.07
Meadow River	WV-KG-55-AT	Surbaugh Creek	-82.19	0.00	-4.33	-86.52
Big Clear Creek	WV-KG-55-BS-16-G	Old Field Branch	-114.52	0.00	-6.03	-120.55

Table 7-2. Fecal Coliform Bacteria TMDLs

TMDL Watershed	Stream Code	Stream Name	Load Allocations (counts/day)	Wasteload Allocation (counts/day)	Margin of Safety (counts/day)	TMDL (counts/day)
Meadow River	WV-KG-55	Meadow River	1.04E+12	2.99E+10	5.64E+10	1.13E+12
Meadow Creek	WV-KG-55-AU	Meadow Creek	3.03E+10	0.00E+00	1.60E+09	3.19E+10
Big Clear Creek	WV-KG-55-BS	Big Clear Creek	1.26E+11	3.18E+07	6.62E+09	1.32E+11
Little Clear Creek	WV-KG-55-CA	Little Clear Creek	7.79E+10	0.00E+00	4.10E+09	8.20E+10
Little Clear Creek	WV-KG-55-CA-3	Beaver Creek	2.11E+10	0.00E+00	1.11E+09	2.22E+10
Otter Creek	WV-KG-55-CH	Otter Creek	5.00E+10	1.14E+07	2.63E+09	5.27E+10
Otter Creek	WV-KG-55-CH-4	Methodist Branch	8.93E+09	0.00E+00	4.70E+08	9.40E+09
Otter Creek	WV-KG-55-CH-8	Smoot Branch	7.56E+09	0.00E+00	3.98E+08	7.96E+09
Otter Creek	WV-KG-55-CH-10	UNT/Otter Creek RM 2.81	5.58E+09	0.00E+00	2.94E+08	5.88E+09

TMDL Watershed	Stream Code	Stream Name	Load Allocations (counts/day)	Wasteload Allocation (counts/day)	Margin of Safety (counts/day)	TMDL (counts/day)
Otter Creek	WV-KG-55-CH-11	UNT/Otter Creek RM 4.03	7.60E+09	0.00E+00	4.00E+08	8.00E+09
Meadow River	WV-KG-55-CM	Callahan Branch	1.20E+10	0.00E+00	6.30E+08	1.26E+10
Buffalo Creek	WV-KG-55-CU	Buffalo Creek	1.42E+10	0.00E+00	7.46E+08	1.49E+10
Meadow River	WV-KG-55-CV	Morris Fork	1.29E+10	0.00E+00	6.80E+08	1.36E+10

UNT = unnamed tributary; RM = river mile.

“Scientific notation” is a method of writing or displaying numbers in terms of a decimal number between 1 and 10 multiplied by a power of 10. The scientific notation of 10,492, for example, is 1.0492×10^4 or 1.0492E+4.

8.0 FUTURE GROWTH

8.1 pH

This TMDL does not include specific future growth allocations. However, the absence of specific future growth allocations does not prohibit the permitting of new or expanded activities in the watersheds of streams for which pH TMDLs have been developed. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits must be "consistent with the assumptions and requirements of any available WLAs for the discharge...." In addition, the federal regulations generally prohibit issuance of a permit to a new discharger "if the discharge from its construction or operation will cause or contribute to the violation of water quality standards."

New facilities that have potential to contribute acidity could be permitted anywhere in the watershed pH impaired streams, provided that effluent limitations are based on the achievement of water quality standards at end-of-pipe.

8.2 Fecal Coliform Bacteria

Specific fecal coliform bacteria future growth allocations are not prescribed. The absence of specific future growth allocations does not prohibit new development in the watersheds of streams for which fecal coliform bacteria TMDLs have been developed, or preclude the permitting of new sewage treatment facilities.

In many cases, the implementation of the TMDLs will consist of providing public sewer service to unsewered areas. The NPDES permitting procedures for sewage treatment facilities include technology-based fecal coliform effluent limitations that are more stringent than applicable water quality criteria. Therefore, a new sewage treatment facility may be permitted anywhere in the watershed, provided that the permit includes monthly geometric mean and maximum daily fecal coliform limitations of 200 counts/100 mL and 400 counts/100 mL, respectively. Furthermore, WVDEP will not authorize construction of combined collection systems nor permit overflows from newly constructed collection systems.

9.0 PUBLIC PARTICIPATION

9.1 Public Meetings

An informational public meeting was held on May 14, 2013 in Rainelle, WV at the Rainelle City Hall. The meeting occurred prior to pre-TMDL stream monitoring and pollutant source tracking and included a general TMDL overview and a presentation of planned monitoring and data gathering activities. A project status update meeting was held in Rainelle on March 10, 2016 at the Rainelle Public Library. A public meeting was held to present the draft TMDLs on September 8, 2016 in Rainelle, WV at Rainelle Elementary. The meeting started at 6:00 PM and provided information to stakeholders intended to facilitate comments on the draft TMDLs.

9.2 Public Notice and Public Comment Period

The availability of draft TMDLs was advertised in various local newspapers beginning on August 25, 2016. Interested parties were invited to submit comments during the public comment period, which began on August 26, 2016 and ended on September 26, 2016. The electronic documents were also posted on the WVDEP's internet site at www.dep.wv.gov/tmdl.

9.3 Response Summary

WVDEP did not receive any written comments from the public on the Draft TMDLs.

10.0 REASONABLE ASSURANCE

Reasonable assurance for maintenance and improvement of water quality in the affected watershed rests primarily with two programs. The NPDES permitting program is implemented by WVDEP to control point source discharges. The West Virginia Watershed Network is a cooperative nonpoint source control effort involving many state and federal agencies, whose task is protection and/or restoration of water quality.

10.1 NPDES Permitting

WVDEP's Division of Water and Waste Management (DWWM) is responsible for issuing non-mining NPDES permits within the State. As part of the permit review process, permit writers have the responsibility to incorporate the required TMDL WLAs into new or reissued permits. New facilities will be permitted in accordance with future growth provisions described in **Section 8**.

Both the permitting and TMDL development processes have been synchronized with the Watershed Management Framework cycle, such that TMDLs are completed just before the permit expiration/reissuance time frames. Permits for existing nonmining facilities in the Meadow River Watershed will be reissued beginning in July 1, 2017 and the reissuance of mining permits will begin January 1, 2018.

10.2 Watershed Management Framework Process

The Watershed Management Framework is a tool used to identify priority watersheds and coordinate efforts of state and federal agencies with the goal of developing and implementing watershed management strategies through a cooperative, long-range planning effort.

The West Virginia Watershed Network is an informal association of state and federal agencies, and nonprofit organizations interested in the watershed movement in West Virginia. Membership is voluntary and everyone is invited to participate. The Network uses the Framework to coordinate existing programs, local watershed associations, and limited resources. This coordination leads to the development of Watershed Based Plans to implement TMDLs and document environmental results.

The principal area of focus of watershed management through the Framework process is correcting problems related to nonpoint source pollution. Network partners have placed a greater emphasis on identification and correction of nonpoint source pollution. The combined resources of the partners are used to address all different types of nonpoint source pollution through both public education and on-the-ground projects.

Among other things, the Framework includes a management schedule for integration and implementation of TMDLs. In 2000, the schedule for TMDL development under Section 303(d) was merged with the Framework process. The Framework identifies a six-step process for developing integrated management strategies and action plans for achieving the state's water quality goals. Step 3 of that process includes "identifying point source and/or nonpoint source management strategies - or Total Maximum Daily Loads - predicted to best meet the needed [pollutant] reduction." Following development of the TMDL, Steps 5 and 6 provide for preparation, finalization, and implementation of a Watershed Based Plan to improve water quality.

Each year, the Framework is included on the agenda of the Network to evaluate the restoration potential of watersheds within a certain Hydrologic Group. This evaluation includes a review of TMDL recommendations for the watersheds under consideration. Development of Watershed Based Plans is based on the efforts of local project teams. These teams are composed of Network members and stakeholders having interest in or residing in the watershed. Team formation is based on the type of impairment(s) occurring or protection(s) needed within the watershed. In addition, teams have the ability to use the TMDL recommendations to help plan future activities. Additional information regarding upcoming Network activities can be obtained from the Watershed Improvement Branch Basin Coordinator, Seth Burdette (Seth.A.Burdette@wv.gov).

The Meadow River Watershed Association is a citizen-based watershed association representing the Meadow River. For additional information concerning the association, contact the above mentioned Basin Coordinator or visit http://www.dep.wv.gov/WWE/getinvolved/WSA_Support/Documents/WVWatershedAssoc.PDF

10.3 Public Sewer Projects

Within WVDEP DWWM, the Engineering and Permitting Branch's Engineering Section is charged with the responsibility of evaluating sewer projects and providing funding, where available, for those projects. All municipal wastewater loans issued through the State Revolving Fund (SRF) program are subject to a detailed engineering review of the engineering report, design report, construction plans, specifications, and bidding documents. The staff performs periodic on-site inspections during construction to ascertain the progress of the project and compliance with the plans and specifications. Where the community does not use SRF funds to undertake a project, the staff still performs engineering reviews for the agency on all POTWs prior to permit issuance or modification. For further information on upcoming projects, a list of funded and pending water and wastewater projects in West Virginia can be found at http://www.wvinfrastructure.com/projects/index.php.

11.0 MONITORING PLAN

The following monitoring activities are recommended:

11.1 NPDES Compliance

WVDEP's DWWM has the responsibility to ensure that NPDES permits discussed in this report contain effluent limitations as prescribed by the TMDL WLAs and to assess and compel compliance. Compliance schedules may be implemented that achieve compliance as soon as possible while providing the time necessary to accomplish corrective actions. The length of time afforded to achieve compliance may vary by discharge type or other factors and is a case-by-case determination in the permitting process. Permits will contain self-monitoring and reporting requirements that are periodically reviewed by WVDEP. WVDEP also inspects treatment facilities and independently monitors NPDES discharges. The combination of these efforts will ensure implementation of the TMDL WLAs.

11.2 Nonpoint Source Project Monitoring

All nonpoint source restoration projects should include a monitoring component specifically designed to document resultant local improvements in water quality. These data may also be used to predict expected pollutant reductions from similar future projects.

11.3 TMDL Effectiveness Monitoring

TMDL effectiveness monitoring should be performed to document water quality improvements after significant implementation activity has occurred where little change in water quality would otherwise be expected. Full TMDL implementation will take significant time and resources, particularly with respect to the abatement of nonpoint source impacts. WVDEP will continue monitoring on the rotating basin cycle and will include a specific TMDL effectiveness component in waters where significant TMDL implementation has occurred.

12.0 REFERENCES

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